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Orbit of the Spectroscopic Binary A Boötis

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ORBIT OF THE SPECTROSCOPIC BINARY A BOÖTIS.

BY REYNOLD K. YOUNG, Ph.D.

The binary character of A Boötis ($\alpha = 14^h\ 14^m$, $\delta = +35°54'$, type G5, mag. 4·8) was announced by Moore in Lick Observatory Bulletin 123. Forty-two spectrograms secured at this observatory with a one-prism spectrograph have been used in determining an orbit. In this, as in many other cases, the Lick Observatory results have been useful in defining the period. The details of their observations were very kindly communicated by mail.

In general an orbit of a late type star determined with a one-prism instrument does not compare favourably with an orbit of the same star based on three-prism results. The accuracy is so much greater in the latter case that the practice has been generally followed of leaving the late types for high dispersion. However, the range of the present binary permits of a fairly accurate determination of the orbit with a one-prism instrument. On this account and also because at the time the number of available binaries was rather limited, the star was placed on the observing programme here.

Table I gives the wave-lengths of the lines used in reducing the measures. The corrections in the third column are computed to make the sum of the weighted residuals of column four vanish. The residuals were taken in the sense, observed minus the mean of the plate. If we compute from Rowland's Preliminary Table of Solar Wave-Lengths the lines which would in one-prism dispersion lie near these, we find that the wave-lengths given in the table are about 0·03 Ångström units larger. The method of combining the various lines in a high dispersion table is arbitrary and the resulting position of the blend uncertain. About all we may say of the wave-lengths given, is that they are homogeneous and that the scale is

not very different from Rowland's. It is doubtful if they would suit another star unless it were exactly the same type. The results from several late type stars, whose orbits have been computed at this observatory, seem to show that the apparent wave-lengths of blends, as measured on low dispersion plates, vary markedly with a slight variation in the spectral type.

The usual method of first finding approximate elements and then correcting these differentially was followed. One correction was found sufficient. The successive steps in the solution and the results are given below. In the radial velocity curve the initial date is Julian Day 2,420,500.

TABLE I

Element.	Wave-Length.	Correction.	Algebraic Residual.	Arithmetic Residual.	Number of times Measured.
Fe	4005·426	−·037	−2·8	4·4	24
Fe	4045·975	+·011	+0·8	1·8	4
Fe	4063·756	+·114	+8·4	8·4	4
Fe	4071·939	−·004	−0·3	2·7	10
Fe+	4092·737	−·023	−1·7	4·1	36
V	4116·643	+·041	+3·0	5·9	16
Fe−Ti	4123·748	+·033	+2·4	4·7	13
Fe	4127·992	−·029	−2·1	4·1	27
Fe+	4132·361	+·021	+1·5	3·3	22
Fe	4191·697	+·011	+0·8	3·3	20
Fe	4202·294	−·032	−2·3	5·2	33
Fe	4236·057	+·013	+0·9	4·3	17
Fe	4250·616	−·013	−0·9	3·3	29
Fe	4258·605	−·010	−0·7	1·5	6
Fe	4271·829	+·006	+0·4	3·1	40
	4275·119	−·003	−0·2	3·3	18
Fe−Ti	4282·722	+·027	+1·9	4·2	36
Cr	4289·766	+·003	+0·2	3·0	34
Ti	4314·866	−·010	−0·7	4·0	30
	4323·612	+·073	+4·8	7·1	15
Fe	4325·792	−·003	−0·2	4·8	12
Fe	4404·890	−·004	−0·3	4·0	37
Fe	4415·225	+·007	+0·5	3·9	40
Fe	4430·469	−·023	−1·6	3·7	35
Fe−Mn	4462·037	−·029	−2·0	4·6	27
Fe−Ti	4549·766	+·015	+1·0	4·4	33
Cr−Ti	4571·891	−·009	−0·6	4·3	39

LICK AND POTSDAM OBSERVATIONS.

Observatory.	Julian Day.	Phase from J. D. 2,420,500	Velocity.	O-C.
Lick	2,417,362·820	254·02	−39·8	+4·9
Lick	7,617·998	85·30	−11·7	+5·8
Lick	7,664·976	132·28	−10·1	+5·8
Lick	7,687·924	155·23	−12·3	+5·8
Lick	7,725·799	193·10	−18·6	+4·9
Potsdam	8,818·46	14·06	−23·3	+8·1
Potsdam	8,839·39	34·99	−32·7	+7·3
Potsdam	9,572·38	132·13	−12·5	+3·4

OTTAWA OBSERVATIONS.

Plate.	Observer.*	Date.	Julian Day.	Velocity.	O–C.
		1915			
6792	C	Feb. 17	2,420,546·821	−40·0	+ 8·0
6825	H	Mar. 1	558·876	−46·5	+ 2·1
6849	H	Mar. 8	565·724	−30·8	+ 7·2
6866	Y	Mar. 14	571·710	−32·3	− 3·8
6882	Y	Mar. 19	576·713	−20·9	+ 1·6
6889	Y	Mar. 23	580·713	−21·8	− 2·3
6895	H	Mar. 29	586·705	−14·0	+ 3·0
6904	Y	April 4	592·691	−28·5	−13·0
6908	Y	April 7	595·724	−11·4	− 3·8
6917	P¹	April 12	600·785	−23·1	− 8·3
6922	Y	April 13	601·705	−16·7	− 1·9
6937	P¹	April 20	608·861	−12·2	+ 2·4
6958	Y	April 28	616·676	−12·5	+ 2·3
6969	H–Y	May 6	624·715	−15·3	0·0
6988	H	May 13	631·697	−12·2	+ 3·4
7008	Y	May 23	641·708	−21·9	− 5·2
7018	Y	May 27	645·756	−19·5	− 2·4
7029	Y	May 30	648·665	−13·0	+ 4·4
7049	Y	June 6	655·599	−26·6	− 8·4
7059	P	June 16	665·613	−12·9	+ 6·5
7068	Y	June 20	669·649	−17·4	+ 2·6
7076	Y	June 27	676·642	−24·6	− 3·6
7088	H	July 8	687·643	−22·5	+ 0·1
7111	Y	July 20	699·580	−28·4	− 3·7
7126	Y	July 27	706·580	−22·6	+ 3·6
7139	H	Aug. 5	715·576	−27·4	+ 0·8
7146	Y	Aug. 10	720·561	−34·0	− 4·8
7158	Y	Aug. 17	727·562	−34·9	− 3·1
7168	Y	Aug. 26	736·544	−38·3	− 3·1
7193	H	Sept. 2	743·546	−41·3	− 3·0
7228	Y	Sept. 10	751·500	−43·2	− 0·2
7257	C	Sept. 17	758·524	−43·1	+ 4·6
7271	Y	Sept. 21	762·512	−48·7	+ 1·0
7281	H	Sept. 22	763·508	−51·9	− 0·8
7288	H	Sept. 27	768·508	−48·7	+ 1·4
7291	Y	Sept. 28	769·493	−54·3	− 4·6
7317	Y	Oct. 3	774·486	−47·4	− 3·4
7321	Y	Oct. 8	779·469	−34·7	− 0·2
7326	Y	Oct. 10	781·474	−28·6	+ 2·9
7340	Y	Oct. 15	786·470	−27·9	− 3·4
7355	Y	Oct. 21	792·462	−17·0	+ 2·5
7359	H	Oct. 23	794·458	−18·[illegible]	+ 0·3

*P=Plaskett; H=Harper; P¹=Parker; C=Cannon; Y=Young.

MEASU[illegible] OF A BOÖTIS.

λ	6792		6825		6849		6866		6882		6889		6895	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4005·426	−52·3	½	......	...	−34·4	1	−38·6	½	−27·5	½	−30·1	½	......	...
4045·975	......	...	......	...	−42·6	½	......	...	......	...	......	...	......	...
4071·939	......	...	......	...	−36·3	½	......	...	−24·5	½	......	...	−20·0	½
4092·748	−60·7	½	−54·2	1	−42·2	1	−40·8	1	−26·9	1	−21·4	1	−10·7	½
4116·643	−59·1	½	−66·2	½	−40·7	½	−28·5	½	−25·6	½	−28·4	½	......	...
4123·754	−59·9	½	......	...	−30·4	½	−45·1	½	......	...	......	...	......	...
4127·990	−64·8	½	−57·2	1	......	...	−32·9	½	−31·0	1	−26·7	½	−12·9	½
4132·336	−48·8	½	−61·7	½	−48·8	½	−32·1	½	−23·9	½	−26·3	1	−14·3	½
4191·806	−53·0	½	−60·0	½	−46·5	½	......	...	−26·3	½	−22·8	½	−15·8	½
4202·294	−54·2	½	−66·3	½	−44·8	½	−40·0	1	−28·6	½	−21·7	½	−19·6*	
4236·072	......	...	−63·1	½	......	...	−44·8	½	−22·4	½	−27·6	½	......	...
4250·616	−61·2	½	−54·9	½	−35·9	½	−42·2	½	−24·8	½	−20·0	½	−17·4	1
4258·614	−53·1	½	−60·0	½	−43·6	½	−39·8	½	−28·7	½	−25·5	½	......	...
4271·829	−47·2	1	−56·3	1½	−42·4	1	−39·1	1	−29·5	½	−25·7	½	−15·5	1
4275·131	−50·5	½	−60·3	½	−39·9	½	−45·2	1	−24·3	½	−28·6	½	......	...
4282·722	......	...	......	...	−39·0	½	−37·9	½	......	...	−27·0	½	−20·6	½
4289·766	−55·4	1	−60·3	½	−48·4	½	−42·9	½	−26·0	½	−21·1	1	......	...
4314·866	......	...	......	...	......	...	−39·3	½	−24·9	½	−31·0	½	−17·4	½
4317·426	−51·7	½	......	...	−41·1	½	......	...	−21·0	½	......	...	......	...
4325·792	−58·7	1	......	...	−41·2	½	......	...	−25·6	½	......	...	......	...
4404·890	−55·0	1½	−55·6	1	−40·2	1½	−40·2	1½	−27·5	1½	−36·6	½	−17·1	1
4415·228	−45·8	1	−57·1	1	−39·2	1	−42·8	½	−26·1	1½	−29·7	1	−12·9	1
4430·503	−51·9	½	−68·8	½	−35·0	½	−45·9	½	−26·6	½	−31·4	1	......	...
4462·092	......	...	−51·3	½	−39·5	½	−43·2	½	−30·9	½	......	...	......	...
4549·766	−51·2	½	......	...	−42·0	½	−30·2	½	......	...	−23·6	½	−19·7	½
4571·891	−58·5	½	−50·5	½	−42·5	½	−43·9	½	−35·9	½	−25·2	½	−17·2	½
Weighted mean	− 55·14		− 58·28		− 40·53		− 40·03		− 26·92		− 26·41		− 16·33	
V_a	+ 15·35		+ 11·99		+ 9·85		+ 7·87		+ 6·17		+ 4·79		+ 2·53	
V_d	+ 0·12		+ 0·07		+ 0·18		+ 0·16		+ 0·13		+ 0·13		+ 0·13	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 39·95		− 46·50		− 30·78		−32·28		− 20·90		− 21·77		− 13·95	

MEASURES OF A BOÖTIS—*Continued.*

λ	6904		6908		6917		6922		6937		6958		6969	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4005·426	....	....	−16·4	½	−16·4	½	−17·3	1	....	....	− 6·0	½	− 3·6	½
4045·975	....	....	....	....	....	....	−13·3	½	....	....	....	....	....	....
4063·756	....	....	....	....	....	....	− 4·5	½	....	....	+ 6·8	½	....	....
4071·939	....	....	−13·7	½	−16·4	½	−16·4	1	....	....	− 4·5	½	....	....
4092·748	−35·2	½	−14·9	1	−22·8	1	−11·2	1	−16·7	½	− 8·2	1	− 6·5	1
4116·643	....	....	− 2·9	½	−20·0	½	−20·0	½	....	....	− 0·7	½	....	....
4123·754	−18·0	½	....	....	....	....	−10·9	½	....	....	....	....	− 7·1	½
4127·990	−24·3	½	−11·4	½	−21·4	½	−15·3	½	....	....	−13·3	½	− 1·9	½
4132·336	....	....	− 9·6	½	−21·5	½	−12·9	½	+ 2·9	½	− 1·9	½	+ 1·0	½
4191·806	....	....	−15·8	½	−15·8	½	−13·3	½	− 0·7	½	− 6·7	1	− 6·7	½
4202·294	−29·6	½	−10·5	½	−21·7	½	−11·5	1	+ 4·2	½	−11·5	½	−12·0	½
4236·072	....	....	....	....	....	....	−15·1	½	+ 1·0	½	....	....	+ 2·1	½
4250·616	−35·3	½	− 5·3	½	−13·2	½	−13·7	½	− 8·4	½	− 8·4	½	− 4·2	½
4271·829	−29·4	½	− 8·0	½	−17·2	1	−15·0	1	+ 1·6	½	− 4·8	1	− 6·4	1
4275·131	....	....	− 5·4	½	−17·8	½	−15·7	½	+ 4·2	½	− 4·3	½	....	....
4282·722	−22·1	½	−11·3	1	−26·0	½	− 5·4	½	−13·0	½	− 3·7	1	− 7·0	½
4289·766	−29·9	½	− 2·1	½	−25·6	½	−12·0	1	− 5·9	½	− 2·6	½	− 3·1	½
4314·866	−27·1	½	− 7·7	½	−17·7	½	−19·3	½	− 7·1	½	....	....	− 6·5	½
4317·426	....	....	....	....	....	....	−18·8	½	....	....	....	....	....	....
4325·792	....	....	....	....	−16·6	½	−17·9	½	....	....	+ 3·5	½	+ 5·7	½
4404·890	−28·9	1	− 4·0	1	−26·0	1	−12·9	1	−14·0	½	− 3·4	1	− 2·2	1
4415·228	−30·8	1	−24·3	½	−23·7	1	−14·1	1	− 7·0	½	− 4·6	1	− 8·7	1
4430·503	....	....	....	....	....	....	−24·8	½	−12·7	½	....	....	− 7·8	½
4462·092	....	....	....	....	....	....	−13·6	½	−15·4	½	− 6·1	½	....	....
4549·766	−21·0	½	−17·0	½	....	....	−30·2	½	....	....	− 7·2	½	....	....
4571·891	−38·7	½	− 9·9	½	−17·2	½	− 9·9	½	−17·2	½	+ 2·8	½	....	....
Weighted mean	− 28·67		− 10·50		− 20·31		− 13·71		− 6·51		− 4·47		− 4·70	
V_a	+ 0·39		− 0·71		− 2·47		− 2·80		− 5·27		− 7·76		− 10·28	
V_d	+ 0·10		+ 0·07		− 0·07		+ 0·07		− 0·19		+ 0·04		− 0·05	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 28·46		− 11·42		− 23·13		− 16·72		− 12·25		− 12·47		− 15·31	

MEASURES OF A BOÖTIS—*Continued.*

λ	6988		7008		7018		7029		7049		7059		7068	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4005·426	......	......	......	......	......	......	+ 1·1	1	−11·3	½			+ 2·0	½
4045·975	......	......	......	......	......	......	+ 7·9	½	− 7·5	½	......	......	......	......
4063·756	......	......	......	......	......	......	+10·8	½	− 2·2	½	......	......	......	......
4071·939	......	......	......	......	......	......	+ 6·2	½	−12·3	½	......	......	......	......
4092·748	− 5·2	½	+11·4	½	− 0·1	½	+ 0·8	1	− 7·0	1	− 0·1	½	+ 3·1	1
4116·643	......	......	......	......	+ 6·4	½	+ 8·2	½	+ 3·1	½	+12·0	½	+13·0	½
4123·754	......	......	......	......	− 2·4	½	+ 7·6	½	− 9·0	½	......	......	+ 1·9	½
4127·990	......	......	......	......	......	......	+ 3·8	½	−13·7	½	......	......	− 2·8	½
4132·336	......	......	− 7·1	½	− 1·4	½	− 1·9	½	− 6·2	½	+ 4·4	½	+ 4·3	½
4191·806	− 3·7	½	......	......	......	......	+ 3·8	1	− 4·7	½	+ 0·3	½	− 1·7	½
4202·294	+ 5·1	½	−13·0	½	−11·5	½	− 3·5	1	−16·6	½	......	......	− 3·4	½
4236·072	......	......	......	......	− 5·2	½	+ 5·2	½	......	......	......	......	+ 6·2	½
4250·616	+ 4·2	½	......	......	−10·0	½	+ 2·6	½	− 8·4	½	+ 2·1	½	− 4·2	½
4271·829	+ 8·0	½	− 1·6	½	− 4·8	½	+ 4·8	½	− 3·7	1	+10·0	½	− 3·7	½
4275·131	......	......	......	......	−11·8	½	+ 4·2	½	− 8·0	½	......	......	+ 5·3	½
4282·722	+ 5·4	1	− 6·4	½	− 4·3	½	+ 6·4	½	− 3·7	½	......	......	+ 2·8	½
4289·766	+ 0·1	1	− 8·5	½	− 1·6	½	+ 9·3	1	− 5·3	½	+ 7·7	½	+ 1·8	½
4314·866	− 4·8	½	− 8·7	½	− 6·9	½	+ 5·7	½	−10·9	½	......	......	......	......
4317·426	+ 4·6	½	+ 2·4	½	......	......	+10·2	½	......	......	......	......	......	......
4325·792	......	......	......	......	......	......	......	......	− 1·5	½	......	......	− 0·9	½
4404·890	+ 3·1	½	−15·8	½	− 4·6	1	+ 4·9	1	−13·4	1	+ 9·5	½	+ 4·9	1
4415·228	− 9·3	1	−13·4	½	− 3·4	½	+ 0·8	½	−16·4	1	+17·5	½	+ 5·6	1
4430·503	− 7·2	½	−16·8	½	− 2·4	½	− 1·8	½	− 6·6	½	+ 4·2	½	+ 5·4	½
4462·092	......	......	−11·1	½	+ 7·4	½	− 4·3	½	−14·1	½	......	......	+ 1·8	½
4549·766	+ 6·5	½	− 5·2	½	......	......	+ 0·6	½	− 3·3	½	+ 3·2	½	......	......
4571·891	+ 4·8	½	+ 0·8	½	+ 3·5	½	+ 6·2	½	− 6·5	½	+ 8·2	½	+ 4·8	½
Weighted mean	+ 0·46		− 6·64		− 3·21		+ 3·74		− 8·21		+ 6·58		+ 2·60	
V_a	− 12·31		− 14·88		− 15·80		− 16·42		− 18·08		− 19·17		− 19·61	
V_d	− 0·07		− 0·12		− 0·19		− 0·08		0·00		− 0·07		− 0·13	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 12·20		− 21·92		− 19·48		− 13·04		− 26·57		− 12·94		− 17·42	

MEASURES OF α BOÖTIS—*Continued.*

λ	7076		7088		7111		7126		7139		7146		7158	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4005·426	− 3·2	½	− 9·0	½	−10·3	½	−14·1	½			−20·1	½		
4071·939											−15·9	½		
4092·748	− 7·4	1	− 6·5	½	− 8·8	½	− 6·5	½	−10·7	½	−17·1	½	−14·9	½
4123·754			+ 4·2	½			0·0	½						
4127·990	− 2·9	½			− 7·6	½	− 1·9	½	−10·4	½	−17·1	½		
4132·336			0·0	½			+ 1·4	½						
4191·806	+ 4·8	½	+ 1·3	½	− 4·0	½								
4202·294	−13·0	½	− 7·5	½	−14·5	½	− 8·5	½			−18·6	½	−15·6	½
4236·072	− 6·2	½							− 3·1	½				
4250·616	− 6·8	½	0·0	½	− 7·8	½					−15·7	½		
4271·829	− 3·2	1	− 0·6	½	−11·8	½	− 4·8	½	− 9·0	½	−18·7	½	−30·5	½
4275·131	− 5·4	½					− 3·8	½	− 8·6	½				
4282·722	− 3·7	½	+ 1·6	½	− 2·7	½	+ 4·8	½	− 5·4	½	− 8·6	½	−17·8	½
4289·766	− 6·9	½	− 1·6	½	− 3·6	½			−19·3	½	−18·8	½		
4314·866	− 8·1	½					+ 5·7	½					−15·8	½
4317·426	− 6·5	½			−17·6	½	+ 0·2	½						
4325·792	− 8·7	½												
4404·890	− 9·3	1	− 4·0	1	− 3·4	1	− 3·4	1	− 4·5	½	−16·4	½	−21·1	½
4415·228	+ 0·8	1	− 1·5	1	− 6·3	½	+ 0·2	1	−14·0	½	−11·2	½	−13·6	½
4430·503	− 4·2	½	− 3·6	1	−13·2	½			− 7·2	½	−16·8	½	−27·1	½
4462·092	− 6·8	½	+ 5·5	½	− 9·0	½			− 6·8	½	−21·5	½		
4549·766	+ 1·3	½	− 0·7	½	− 6·5	½	− 9·1	½	− 7·2	½	−13·1	½	−11·0	½
4571·891	− 2·5	½	+ 2·8	½	− 6·9	½	− 4·9	½					−19·8	½
Weighted mean	− 4·87		− 1·51		− 8·08		− 2·83		− 8·85		− 16·40		− 18·72	
V_a	− 19·24		− 20·66		− 19·93		− 19·27		− 18·03		− 17·16		− 15·66	
V_d	− 0·16		− 0·19		− 0·15		− 0·19		− 0·20		− 0·20		− 0·22	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 24·55		− 22·54		− 28·44		− 22·57		− 27·36		− 34·04		− 34·88	

MEASURES OF A BOÖTIS—*Continued.*

λ	7168		7193		7228		7257		7271		7281		7288	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4092·748	−30·0	½			−37·8	½			−51·7	½	−61·3	½		
4123·754	−14·7	½												
4127·990	−23·7	½			−28·5	½					−65·5	½		
4132·336									−36·2	½				
4202·294	−22·6	½							−51·4	½	−51·9	½		
4236·072					−29·1	½			−46·7	½				
4250·616	−26·8	½			−35·7	½								
4271·829	−31·5	½	−30·0	½	−36·8	½			−39·0	½	−43·2	½	−43·9	½
4282·722	−27·5	½					−29·6	½	−33·4	½	−47·8	½	−36·6	½
4289·766	−28·6	½					−32·4	½	−39·4	½	−42·1	½		
4314·866	−32·9	½			−25·2	½	−32·4	½	−45·1	½	−35·1	½	−53·9	½
4317·426											−32·0	½		
4404·890					−36·5	½			−36·4	½	−51·8	½	−43·0	½
4415·228	−20·2	½			−25·9	½	−37·2	½	−43·2	½	−35·4	½	−43·4	½
4430·503	−15·6	½	−31·3	1	−36·1	½	−33·1	½	−46·9	½	−46·3	½	−44·7	½
4462·092	−28·3	½	−22·8	½			−36·9	½			−40·0	½	−45·7	½
4549·766	−19·6	½			−36·6	½	−36·6	½			−51·6	½	−45·7	½
4571·891	−17·1	½	−30·3	½	−38·9	½	−43·6	½	−40·9	½	−40·9	½	−44·3	½
Weighted mean	− 24·22		− 29·14		− 33·37		− 35·22		− 42·52		− 46·06		− 44·58	
V_s	− 13·57		− 11·66		− 9·27		− 7·35		− 5·67		− 5·34		− 3·60	
V_d	− 0·22		− 0·23		− 0·23		− 0·25		− 0·25		− 0·25		− 0·25	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 38·29		− 41·31		− 43·15		− 43·10		− 48·72		− 51·93		− 48·71	

MEASURES OF A BOÖTIS—*Concluded.*

λ	7291		7317		7321		7326		7340		7355		7359	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4092·746	−57·6	½	−55·8	½			−32·3	½	−27·3	½				
4127·990	−57·9	½			−45·7	½	−30·4	½	−35·0	½				
4202·294					−19·6	½	−19·6	½	−43·7	½	−22·6	½		
4236·072					−38·4	½					−25·9	½	−13·0	½
4250·616			−48·8	½	−39·9	½	−33·1	½						
4271·829	−47·5	½	−51·5	½			−29·4	½	−19·2	½	−22·4	½	−31·9	½
4275·131									−36·5	½				
4282·722	−35·5	½	−40·9	½	−42·5	½	−39·5	½	−30·1	½	−15·1	½	−22·7	½
4289·766	−56·1	½					−28·0	½	−28·0	½	−25·3	½	−24·8	½
4314·866	−51·2	½	−46·2	½	−30·8	½	−28·0	½	−42·9	½	−26·4	½		
4317·426			−36·5	½			−15·4	½	−18·7	½			−13·2	½
4325·792							−32·1	½					−31·0	½
4404·890	−43·5	½	−35·3	½	−27·0	½	−24·7	½	−34·2	1				
4415·228	−46·2	½	−43·2	½	−30·1	½	−31·3	½	−23·6	1			−19·9	½
4430·503	−48·3	½	−43·3	½			−29·5	½	−27·0	1	−16·2	½	−24·1	½
4462·092	−61·7	½			−28·3	½	−28·3	½			−19·1	½	−36·1	½
4549·766	−47·2	½	−45·8	½	−35·9	½	−24·8	½	−27·4	½	−18·3	½	−9·9	½
4571·891	−53·8	½	−51·6	½	−40·9	½	−38·9	½	−33·3	½	−22·4	½	−28·4	½
Weighted mean	−50·54		−45·35		−34·46		−29·08		−30·10		−21·37		−23·27	
V_a	−3·26		−1·49		+0·29		+1·00		+2·78		+4·91		+5·61	
V_d	−0·25		−0·25		−0·25		−0·26		−0·27		−0·27		−0·28	
Curv.	−0·28		−0·28		−0·28		−0·28		−0·28		−0·28		−0·28	
Radial Velocity	−54·33		−47·37		−34·70		−28·62		−27·87		−17·01		−18·22	

NORMAL PLACES.

	Julian Day.	Phase from J.D. 2,420,500	Velocity.	Weight.	O–C Preliminary.	O–C Final.
1.	2,420,728·22	16·27	−35·7	1·0	−2·9	−3·6
2.	753·09	41·14	−41·9	1·3	+2·8	+2·1
3.	763·01	51·06	−50·3	0·7	−0·7	−0·3
4	769·00	57·05	−51·5	0·7	−2·3	−1·5
5	772·66	60·71	−47·0	0·7	−0·7	−0·5
6	780·57	68·62	−31·6	1·3	+2·9	+1·1
7.	790·94	78·99	−21·2	1·7	+0·7	−0·5
8	596·22	96·22	−16·3	1·3	−1·4	−1·1
9	620·48	120·48	−13·0	1·3	+1·3	+2·1
10.	645·38	145·38	−18·3	1·0	−1·9	−1·2
11.	674·86	174·86	−19·4	1·3	+0·9	+1·3
12	707·23	207·23	−26·1	1·0	+0·5	+0·3

PRELIMINARY ELEMENTS.

T = Julian Day 2,420,562·00
K = 18·0 km.
ω = 225°
e = 0·50
γ = −25·64 km.
P = 211·95 days
μ = 1°·6985.

OBSERVATION EQUATIONS.

	x	y	z	p	q	$-n$	Weight.
1	1	−0·398	+0·926	−0·645	+0·438	+2·91	1·0
2	1	−1·057	+1·189	−0·358	+0·708	−2·75	1·3
3	1	−1·327	−0·166	+0·124	+0·344	+0·72	0·7
4	1	−1·312	−1·149	+0·641	−0·595	+2·26	0·7
5	1	−1·148	−0·973	+0·962	−1·361	+0·71	0·7
6	1	−0·491	+1·205	+1·345	−1·936	−2·87	1·3
7	1	+0·210	+1·558	+1·180	−0·985	−0·65	1·7
8	1	+0·598	−0·062	+0·661	−0·183	+1·44	1·3
9	1	+0·630	−0·923	+0·174	+0·062	−1·29	1·3
10	1	+0·513	−0·970	−0·144	+0·133	+1·91	1·0
11	1	+0·295	−0·587	−0·407	+0·192	−0·92	1·3
12	1	−0·054	+0·208	−0·600	+0·296	−0·50	1·0

where

$$x = d\gamma$$
$$y = dK$$
$$p = Kde$$
$$z = Kd\omega$$
$$q = \frac{K\mu}{(1-e^2)^{\frac{3}{2}}}dT$$

NORMAL EQUATIONS.

$$\begin{array}{rrrrrr}
13\cdot300x & -2\cdot265y & +\ 2\cdot262z & +3\cdot665p & -3\cdot439q & -2\cdot509=0 \\
 & +6\cdot719y & -\ 1\cdot763z & -0\cdot705p & +1\cdot091q & +1\cdot620=0 \\
 & & +12\cdot864z & +2\cdot972p & -3\cdot051q & -9\cdot987=0 \\
 & & & +7\cdot427p & -7\cdot567q & -3\cdot906=0 \\
 & & & & +9\cdot196q & +5\cdot042=0
\end{array}$$

whence

$$d\gamma = +0\cdot02 \text{ km.}$$
$$dK = +0\cdot02 \text{ km.}$$
$$de = +0\cdot04$$
$$d\omega = -1^\circ\cdot58$$
$$dT = -0\cdot82 \text{ day.}$$

When these corrections were added to the approximate elements and the normal places represented, Σpv^2 was lowered from 44 to 34. The individual observations were represented graphically and the residuals are given in the tables of the observations under the heading O–C. The Lick and Potsdam observations are very consistently positive. Part of this difference may be due to the scale of wave-lengths used, but some other factor must be operative also.

The final elements are

T	= J. D. 2,420,561·18	±0·90
K	= 18·02 km.	±0·59
ω	= 223°·42	±2°·60
e	= 0·54	±0·024
γ	= 25·62 km.	±0·45
P	= 211·95 days	
μ	= 1°·6985	
$a \sin i$	= 44,000,000 km.	

$$\frac{m_1^3 \sin^3 i}{(m + m_1)^2} = 0 \cdot 076 \odot$$

The residuals from our own measures are often very large, in one case thirteen kilometres. The agreement of the individual lines would lead one to expect a probable error for a single plate between one-half and one kilometre, whereas it actually came out 2·8. The measures were so discordant, that an investigation was undertaken to try and locate some reason for the erratic manner in which the velocities behaved.

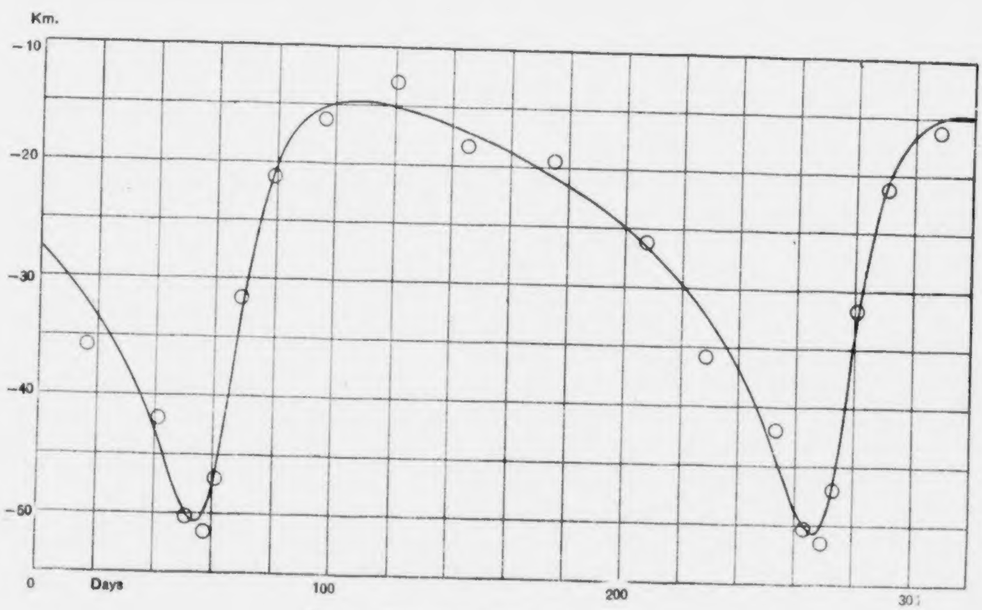
Part of the trouble may lie in the star itself, the conditions there changing irregularly so as to alter the apparent wave-lengths of the lines. The effect of such changes are small, provided they do not arise from a third body, for the higher the dispersion employed and the more perfect the method of observation the smaller do the variations in velocity become. This is practically conclusive evidence, so far as one-prism work is concerned, that the anomalies in velocities, for good line stars at least, arise within the spectrograph.

Flexure, temperature change, poor focus, irregular guiding, nonuniform illumination of the collimator, each of these plays its part in the final result. The first three causes have been well met, and the modern spectrograph is almost mechanically perfect and free from these defects. With good focus the danger from nonuniform illumination of the collimator vanishes.

The effect of guiding was tested by taking plates of Arcturus, placing the stellar image first on one side of the slit and then on the other. The results of these experiments were published in the Astronomical Society of the Pacific Publications, August, 1915. They showed that velocities, as much as thirteen kilometres from the truth, could be obtained by guiding with the star not perfectly central on the slit. When one remembers that the guiding is done by blue-green light, while the plate registers the blue and violet and that the images of the star in these colours do not coincide, one can readily see that error could be introduced in this way. There are other considerations which lend plausibility to the suspicion that this source of error is very important. It would be larger in one-prism than in three-prism instruments. It would be larger the smaller the telescope; for with a small objective the guiding image is fainter, the power is lower and, consequently, it is more difficult to bisect the star with the slit of the spectroscope. It would be larger in short-focus than in long-focus telescopes, because the latter require more frequent attention in guiding and the image is shifted often from place to place, so that in the mean the whole slit is better covered. Moreover, the effective image (the tremor disk) is larger for long-focus instruments, so that a slight displacement of the star probably affects the centre of intensity of the image less than the same displacement in a telescope of shorter focus. These latter factors I believe to be very important. With the short-focus instrument used at this observatory and a clock which runs very uniformly, a star will often stay in position for fifteen minutes. This fact often coupled with that of a temperature in the dome in winter as low as minus 20° Fahrenheit, when to place the eye to the guiding telescope is to receive the sensation of an electric shock, does not contribute to constant attention to the position of the star image on the slit. One might have a personal equation in bisecting the star image, so that a run of plates would all be consistently too high or too low. Part of the difference between the Lick Observatory and Potsdam and the Ottawa observations might be accounted for in this way. Experiment to

ascertain the best method of guiding to secure consistent results would probably be worth while. Thus it might be found that slight illumination of the slit, so that it could be seen without the aid of the star's light would add to the accuracy. Personally, I find guiding easier in the twilight than on a dark night. In the case of A Boötis, the majority of the latter half of the plates were taken under these conditions and in general they give smaller residuals than the early plates, but the evidence is not sufficient to show whether this is to be ascribed to the twilight or not.

Dominion Observatory,
Ottawa,
November, 1915.



RADIAL VELOCITY CURVE OF A BOÖTIS.